NEWTON'S APPLE®

Multimedia

Sewers

Everglades

Teacher's Guide

NEWTON'S APPLE Multimedia

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Introduction

Welcome to the *Newton's Apple Multimedia Collection*™!

Drawing from material shown on public television's Emmy-award-winning science series, the multimedia collection covers a wide variety of topics in earth and space science, physical science, life science, and health. Each module of the *Newton's Apple Multimedia Collection* contains a CD-ROM, a printed Teacher's Guide, a video with two *Newton's Apple* ® segments and a scientist profile, and a tutorial video.

The Teacher's Guide provides three inquiry-based activities for each of the topics, background information, assessment, and a bibliography of additional resources.

The CD-ROM holds a wealth of information that you and your students can use to enhance science learning. Here's what you'll find on the CD-ROM:

- two full video segments from *Newton's Apple*
- additional visual resources for each of the *Newton's Apple* topics
- background information on each topic
- a video profile of a living scientist working in a field related to the *Newton's Apple* segments
- an Adobe Acrobat ® file containing the teacher's manual along with student reproducibles
- UGather ® and UPresent ® software that allows you and your students to create multimedia presentations
- QuickTime ® 3.0, QuickTime ® 3 Pro, and Adobe Acrobat® Reader 3.0 installers in case you need to update your current software

The *Newton's Apple Multimedia Collection* is designed to be used by a teacher guiding a class of students. Because the videos on the CD-ROM are intended to be integrated with your instruction, you may find it helpful to connect your computer to a projection system or a monitor that is large enough to be viewed by the entire class. We have included a videotape of the segments so that you can use a VCR if it is more convenient. Although the CD-ROM was designed for teachers, it can also be used by individuals or cooperative groups.

With the help of many classroom science teachers, the staff at *Newton's Apple* has developed a set of lessons, activities, and assessments for each video segment. The content and pedagogy conform with the National Science Education Standards and most state and local curriculum frameworks. This Teacher's Guide presents lessons using an inquiry-based approach.

If you are an experienced teacher, you will find material that will help you expand your instructional program. If you are new to inquiry-based instruction, you will find information that will help you develop successful instructional strategies, consistent with the National Science Education Standards. Whether you are new to inquiry-based instruction or have been using inquiry for years, this guide will help your students succeed in science.

WE SUPPORT THE NATIONAL SCIENCE EDUCATION STANDARDS

The *National Science Education Standards* published by the National Research Council in 1996 help us look at science education in a new light. Students are no longer merely passive receivers of information recorded on a textbook page or handed down by a teacher. The Standards call for students to become active participants in their own learning process, with teachers working as facilitators and coaches.

Newton's Apple's goal is to provide you with sound activities that will supplement your curriculum and help you integrate technology into your classroom. The activities have been field tested by a cross section of teachers from around the country. Some of the activities are more basic; other activities are more challenging. We don't expect that every teacher will use every activity. You choose the ones you need for your educational objectives.

Teacher's Guide

We suggest you take a few minutes to look through this Teacher's Guide to familiarize yourself with its features.

Each lesson follows the same format. The first page provides an overview of the activity, learning objectives, a list of materials, and a glossary of important terms. The next two pages present a lesson plan in three parts: ENGAGE, EXPLORE, and EVALUATE.

- ENGAGE presents discussion questions to get the students involved in the topic. Video clips from the *Newton's Apple* segment are integrated into this section of the lesson.
- EXPLORE gives you the information you need to facilitate the student activity.
- EVALUATE provides questions for the students to think about following the activity. Many of the activities in the collection are open-ended and provide excellent opportunities for performance assessment.

GUIDE ON THE SIDE and TRY THIS are features that provide classroom management tips for the activity and extension activities.

Using the CD-ROM

When you run the *Newton's Apple* CD-ROM, you will find a main menu screen that allows you to choose either of the two *Newton's Apple* topics or the scientist profile. Simply click on one of the pictures to bring up the menu for that topic.

Main Menu

Once you have chosen your topic, use the navigation buttons down the left side of the screen to choose the information you want to display.

Topic Menu

The Background button brings up a short essay that reviews the basic science concepts of the topic. This is the same essay that is in the Teacher's Guide.

Playing the Video

The Video button allows you to choose several different clips from the video segment. We have selected short video clips to complement active classroom discussions and promote independent thinking and inquiry. Each video begins with a short introduction to the subject that asks several questions. These introductory clips can spark discussion at the beginning of the lesson. The Teacher's Guide for each activity presents specific strategies that will help you engage your students before showing the video. Each of the individual clips are used with the lesson plans for the activities. The lesson plan identifies which clip to play with each activity.

Video Menu

Once you select a video and it loads, you'll see the first frame of the video segment. The video must be started with the arrow at the left end of the scroll bar. As you play the video, you can pause, reverse, or advance to any part of the video with the scroll bar. You can return to the Clips Menu by clicking on the Video button.

Multimedia Tools

The *Newton's Apple* staff has designed a product that is flexible, so that you can use it in many different ways. All of the video clips used in the program are available for you to use outside the program. You may combine them with other resources to create your own multimedia presentations. You will find all the video clips in folders on the CD-ROM. You may use these clips for classroom use only. They may not be repackaged and sold in any form.

You will also find a folder for UGather™ and UPresent™. These two pieces of software were developed by the University of Minnesota. They allow you to create and store multimedia presentations. All of the information for installing and using the software can be found in the folder. There is an Adobe Acrobat® file that allows you to read or print the entire user's manual for the software. We hope you will use these valuable tools to enhance your teaching. Students may also wish to use the software to create presentations or other projects for the class.

Technical Information

Refer to the notes on the CD-ROM case for information concerning system requirements. Directions for installing and running the program are also provided there.

Make sure you have the most current versions of QuickTime® and Adobe Acrobat® Reader installed on your hard drive. The installation programs for QuickTime 3, QuickTime Pro, and Acrobat Reader 3.0 can be found on the CD-ROM. Double-click on the icons and follow the instructions for installation. We recommend installing these applications before running the *Newton's Apple Multimedia* program.

Trouble Shooting

There are several Read-Me files on the CD-ROM. The information found there covers most of the problems that you might encounter while using the program.

Integrating Multimedia

We suggest that you have the CD-ROM loaded and the program running before class. Select the video and allow it to load. The video usually loads within a couple of seconds, but we recommend pre-loading it to save time.

All of the video segments are captioned in English. The captions appear in a box at the bottom of the video window. You can choose to play the clips in either English or Spanish by clicking one of the buttons at the bottom right of the screen. (You can also choose Spanish or English soundtracks for the scientist profile.)

The Resources button provides you with four additional resources. There are additional video clips, charts, graphs, slide shows, and graphics to help you teach the science content of the unit.

Resources Menu

The other navigation buttons on the left side of the window allow you to go back to the Main Menu or to exit the program.

Down the Drain

What happens to all the water after it goes down the drain? How do they clean wastewater so that it can be used again? Are there different ways to clean different substances from wastewater? Do water treatment plants clean bacteria from the water? How are harmful substances taken out of water?

Themes and Concepts

- constancy and change
- systems
- earth science
- ecology and environment

National Science Education Standards

Content Standard A: Students should develop abilities necessary to do scientific inquiry.
Content Standard C: Students should develop an understanding of populations and ecosystems.
Content Standard D: Students should develop an understanding of the structure of the earth system.
Content Standard E: Students should develop abilities of technological design.

Activities

1. *That's a Lot of Water—Approx. 20 min. prep; 60 min. class time*
How do you measure the water volume in different containers? How do you measure water flow? Students devise ways of measuring water volume and calculate how much water is in different-shaped containers. They also figure out the volume of water coming from a tap.

2. *Clean It Up!—Approx. 30 min. prep; 60 min. class time*
How do you take the waste out of wastewater? Students develop criteria to evaluate how well different methods of cleaning water work. They figure out ways to clean different kinds of wastes out of water, then judge the effectiveness against their criteria.

3. *That's Enough!—Approx. 60 min prep; 110 min. class time*
What determines if a substance in the water is harmful? Students work with brine shrimp to discover how minuscule amounts of a substance in water can be harmful to living things.

More Information

Internet

Newton's Apple
http://www.ktca.org/newtons
(The official *Newton's Apple* web site with a searchable database of science activities on many different subjects.)

Material Safety Data Sheets (MSDS)
http://siri.org/MSDS/index/grep.cgi
(Information about chemicals and most common consumer cleaning products.)

North River Treatment Plant
The City of New York—Department of Environmental Education
http://nycdoitt.ci.nyc.ny.us/html/dep/html/northri.html
(Read about the construction, history, and processes at work at this huge treatment plant.)

A Guide to Wastewater Treatment—Greater Vancouver Regional District
http://www.gvrd.bc.ca/sewers/bro/wwguide.html#what
(Explains what wastewater treatment is, why it's done and simple explanations what processes are used to treat water.)

Abernathy Home Page—University of Texas
http://klingon.util.utexas.edu/londonsewers/londontext1.html
(Read about the development of the London sewers system.)

Internet Search Words

sewers
wastewater
water treatment
treatment plants

Sewers

Background

A few decades ago, many people would have laughed at the notion of water being bottled and sold in grocery stores. With the realization in the 1960s and 1970s that we were severely polluting many of our rivers, streams, and lakes, clean water took on a new importance. People realized that almost everyone lives downstream of someone else and that water conservation and quality actually matter.

While most of us have had our consciousness raised about the role and value of water in life, we often don't think about the fact that whenever we use water, we usually lower its quality. Whether we use it to wash the kitchen floor, brush our teeth, or eliminate it as waste, we typically flush it away or pour it down the drain and forget about it.

But what happens to water after it enters the sewer system? How does it get cleaned up and returned to nature, perhaps to be used as drinking water by somebody living downstream? So much wastewater is produced in cities and towns that large treatment plants work around the clock to keep the water supply clean. Many of the methods used at these plants mimic natural processes—filtering, settling, microbial decay—but they must happen faster and with a much larger volume of water.

Millions of gallons flow through sewer pipes into treatment plants near big cities every day. There are many different designs for treatment plants, but most use the same basic stages to clean wastewater. Water flowing in—called influent—initially runs through some type of filtering system. Large objects are screened out and moved to "digester" tanks where the solid material is treated and dried.

Meanwhile, the water moves into tanks where heavier particulates are allowed to settle out. As this sludge sinks to the bottom of the water, oil and grease are skimmed off the water's surface. The water is then pumped over microbe-coated rocks. Aerobic bacteria can eat as much as 25 percent of the tiny particles still in the water. The water is then moved to circulation tanks where the water currents encourage "flocculation," a process in which more of the remaining particulate matter in the water sticks together and then sinks to the bottom.

Water next flows to an aeration tank, where oxygen is mixed in. During this stage, microorganisms can be added to consume more of the particulates and make the water cleaner.

Finally, chlorine is added. The chlorine is usually left in the water for at least 30 minutes so it can kill all of the remaining bacteria and sterilize the water. After the chlorine has done its job, some treatment plants add sulfur dioxide to neutralize the chlorine so the water can be released back into nature.

The water you drink and bathe in has been used and cleaned millions of times in Earth's history. But humans are putting ever-increasing demands on the water supply, while at the same time insisting that it be clean. Sewage treatment plants might seem a little disgusting, but they are very important in cleaning up the water you might use to quench your thirst next week.

Books and Articles

Christen, Kris. "Wastewater Reuse: water shortage solution or long-term nightmare." *Environmental Science and Technology*, Oct 1, 1998, p. 447.

Crites, Ron and Tchobanogolus, George. *Small and Decentralized Wastewater Management Systems.* New York, NY: McGraw Hill Textbooks, 1998.

Gillies, M.T., ed. *Potable Water from Wastewater*. Park Ridge, NJ: Noyes Data Corporation, 1981.

Mueller, Karen. *Flush! Treating Wastewater*. Minneapolis, MN: Carolrhoda Books, 1995.

National Environment Association. "Use of Reclaimed Wastewater in Municipal Drinking-Water Supplies." *Journal of Environmental Health*, June 1998, p. 39.

Community Resources

Local wastewater treatment plants

Video & Stills

Video Segments

Introduction

00:00 to 00:55—Dave Huddleston thinks about all the stuff that goes down the kitchen sink and asks some questions about where it goes. (55 sec.)

Video Clip 1

00:44 to 01:44—Peggy Knapp "dives" into the subject of sewers and follows the sewer pipe from her house to the wastewater treatment plant. (1 min.)

Video Clip 2

01:47 to 03:24—Treatment plant supervisor Joanne Hart shows Peggy Knapp how skimmers remove suspended matter in wastewater. (1 min. 37 sec.)

Video Clip 3

05:39 to 06:11—Peggy Knapp examines the cleaned water that is released from the treatment plant. (32 sec.)

Video Clip 4

03:19 to 05:07—Peggy Knapp learns how water treatment plants use bacteria and other microorganisms to remove dissolved pollutants. (1 min. 48 sec.)

Additional Resources

Button A

Slide Show: Charts showing the average daily water use per person daily and a comparison of annual use by country.

Button B

Diagram: The different stages water goes through at a wastewater treatment plant.

Button C

Video: Newton's Apple host David Heil finds out how the city of St. Paul, MN gets its drinking water.

Button D

Slide Show: Series of photos showing the construction of sewers.

Unit Assessment Answer Key

The Unit Assessment on the following page covers the basic concepts presented in the video segment and the background on the Unit Theme section in this guide. The assessment does not require completing all of the activities. The Unit Assessment may be used as a pre- or post-test. However, students should view the complete *Newton's Apple* video before doing this assessment. There is additional assessment at the end of each activity.

Think about it

1. Methods include: (A) Large solid objects are screened out. (B) Settling tanks allow heavy particulate matter to sink and oil and water to rise to the surface. The heavy sludge and lighter oils are skimmed off. (C) Microbes consume solid particles. (D) Circulation tanks make water flow in a way to cause particles to clump together so they can be more easily removed. (E) Aerobic bacteria digest microscopic organic material. (F) Chlo rine is added to sterilize the water and kill any remaining bacteria.
2. Aerating the water serves two purposes. It stirs up the water so that bacteria can more readily come in contact with organic particles. Aeration also adds oxygen to the water, which helps sustain the aerobic bacteria.
3. If the tanks of a wastewater treatment plant become flooded, untreated sewage can be washed back into the water supply. This can pollute the entire water supply for some time. Boiling water for a minimum of three minutes can kill most of the dangerous microbes in the water.
4. The chlorine is added to kill any bacteria that may remain in the water after it has been through primary and secondary treatment. The chlorine is removed to prevent damage to plant and animal life when the water is released from the treatment plant back into the environment.
5. Answers will vary. The further downstream water moves, the more pollutants can build up along the way. People who live downstream deserve clean water just like the people who live upstream.

What would you say?

6. a 7. c 8. d 9. b 10. c

NEWTON'S APPLE Multimedia

Unit Assessment

What do you know about Sewers?

Write the answers to these questions in your journal or on a separate piece of paper.

Think about it

1. Describe three different methods treatment plants use to clean wastewater.
2. What is the purpose of aerating the water as it goes through the treatment plant?
3. Sometimes after severe floods, people are told to boil their water for several minutes before using for cooking or drinking. Why?
4. Why is chlorine first added to the water, then later taken out?
5. Explain what this statement—"Everybody lives downstream from somebody"— has to do with wastewater treatment.

What would you say?

6. Which of the following is probably not removed from wastewater when it goes through a treat ment plant?
   a. small amounts of lawn fertilizers
   b. bacteria
   c. small chunks of wood
   d. oil and grease
7. What is cleaned from the water when it first enters a treatment plant?
   a. suspended materials
   b. bacteria
   c. large solids
   d. chlorine
8. Which of the following is not used as part of the treatment of wastewater?
   a. chlorine
   b. skimmers
   c. oxygen
   d. carbon dioxide
9. Bacteria are used to remove _____
   a. dissolved chemicals.
   b. microscopic organic matter.
   c. excess chlorine.
   d. suspended particles.
10. Most household drains _____
    a. connect directly to sewage treatment plants.
    b. empty into a series of pipes that carry the water to streams.
    c. link to larger and larger pipelines that connect to a treatment plant.
    d. carry only one kind of wastewater.

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Activity 1

That's a Lot of Water

Where does the water go when it goes down the drain? Is it only water that goes down the drain? How much water do you use every day? How can you accurately estimate the volume of wastewater you produce each day?

Getting Ready

Overview

Students devise methods for calculating water flow. They use their methods to estimate the amount of water they use on a daily basis.

Objectives

After completing this activity, students will be able to—

- measure the flow rate of water
- calculate the volume of flowing water by measuring the time and using the flow rate
- estimate the amount of water used by an individual in his or her daily activities

Time Needed

Preparation: Approximately 20 minutes
Classroom: Approximately 60 minutes

Materials

For the teacher:

- various products you would normally find under the sink in a home—cleaning products, cooking oil, plant food, personal care products, etc.
- soap for washing hands
- medium-sized, clear bucket or container in sink to catch wastewater

For each group of students:

- stopwatch or a clock with a second hand
- access to a flowing water source—faucet, drinking fountain, etc.
- empty clear plastic 2L plastic soda bottle (label removed)
- permanent dark-colored marker
- 500 mL graduated cylinder

Important Terms

flow rate — Volume of water that flows out a faucet during a given time, expressed in units of volume per time (liters per minute).

sewer — A system of underground pipes that collect and deliver wastewater to treatment facilities or streams.

wastewater — Polluted water that has been used in homes, schools, businesses, and industries and is not suitable for reuse unless the contaminants are removed.

Sewers

Here's How

Video Clip 1
00:44 to 01:44—Peggy Knapp "dives" into the subject of sewers and follows the sewer pipe from her house to the wastewater treatment plant. (1 min.)

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the necessary materials for the teacher demo and the student experiments.
- Make a copy of Activity Sheet 1 for each student.
- Review the Background information on page 8. Put a bucket or other container into the sink before students enter the classroom to catch the wastewater during the Engage portion of the lesson. The container should not be visible to the students and ideally should be transparent so students will be able to get an appreciation for the water quality when they are shown the sample of wastewater.

Engage (Approx. 15 min.)

Next to the lab sink, place a number of products you would normally find under a kitchen or bathroom sink in a home (cleaning products, personal care products, etc.). Start the lesson by adding a few more bottles to the collection. Tell students you are cleaning out an old cupboard. Ask them what would be the best way to dispose of the unused products. At least one student will probably suggest pouring one or more of the products down the drain for disposal. You may want to record the students' ideas.

Wash your hands in the sink using plenty of soap and catch the wastewater in the hidden bucket. Do not be frugal; use a lot of water. Ask the students a series of questions—Where does the water go? Was it only water going down the drain? How much water went down the drain while I was washing my hands? (Have students guess and record their answers.) How can you measure the amount of water that went down the drain? Accept all student answers.

Next, show the students the wastewater collected in the hidden container.

Have students suggest ways to estimate the amount of water you used washing your hands. Then have them use one of these methods to estimate the volume in the container. Compare this estimate to the guesses students made previously.

Play Video Clip 1 [00:44 to 01:44]. Ask students how a treatment plant might calculate how much water it processes. Accept all answers. Tell students that they are going to figure out how to calculate volumes of water.

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:55]. Find out what students already know about sewers and wastewater treatment. As a class, discuss the questions posed by Dave Huddleston.

- The methodology for this activity is fairly open-ended. Some groups may need more help than others. If students become frustrated or off track, ask a series of questions that will help them figure it out for themselves.

- Let students discover for themselves how they might make graduation marks to measure smaller volumes on the side of the 2L bottle. Again, lead them to discover this on their own.

- Some volumes might be more understandable for students in standard measurement rather than metric. Use the following formulas:
  liters = gallons x 3.77
  gallons = liters/3.77

- When discussing the volume of water individuals consume, you may wish to refer to the chart on water usage found at Resource Button A on the CD-ROM.

- If it is appropriate, view the entire *Newton's Apple* video segment on Sewers after completing the activity.

Activity 1

Explore (Approx. 45 min.)

Students should work in small groups. Challenge groups to come up with a way of accurately calculating water flow. Explain that flow rate is measured by determining how much water flows out of a source—a faucet, hose, pipe, etc.—over a certain amount of time. For example flow rate could be measured in liters per minute. Provide each group with the required materials.

Each group should agree upon a method for measuring flow rate of a faucet or a water fountain. They should write a description of their group's method in their science journals. Using their 2L bottle and a stopwatch, groups should test their methods. They determine the flow rate for 5 seconds, 15 seconds, and 30 seconds. Students should measure the flow rate three times for each time period and average their results. What would the flow rate be per minute, per hour, per day?

After groups have completed the activity, bring the class back together for groups to share the methods they developed to determine flow rate. Did all groups come up with the same flow rate for the same water sources? Discuss any differences and what might account for them.

Evaluate

1. Given what you know about determining flow rate, how would you determine an accurate estimate of how much water you use in a day? (First, calculate the flow rate for showers, faucets, etc. Then, log the amount of time each water source was used. Multiplying the flow rate by the amount of time will provide a fairly accurate estimate of the volume of water being used.)

2. Write three "real life" problems for classmates to solve. Each problem should require classmates to calculate either the volume of water that would flow during a certain time period or the amount of time it would take to fill a container of a certain volume—swimming pool, bathtub, etc. (Answers will vary. Student problems should reflect an understanding of flow rate and volume and should be based on realistic applications.)

3. The city planner has hired you to design a water treatment facility for a small town. How would you determine how large a facility to build? How could you apply your knowledge of flow rate to this project? (Answers will vary. Student answers should reflect an understanding of estimating the volume of water that would be needed on a daily basis, the population of the town, its potential growth, etc.)

Try This

Use the measurement methods you developed in this activity to estimate the daily volume of water that goes down the drain at your home. Brainstorm at least 10 ways you can reduce the amount of water put down the drain at your home. Share this information with the class.

If you belong to a municipal water system, you pay for the amount of water you use at your home. If your family pays for water, look at the water meter for your house or apartment and monitor the amount of water you use. Look at a water bill to determine the cost of the water you use for a month. Graph your water use by month using a bar graph.

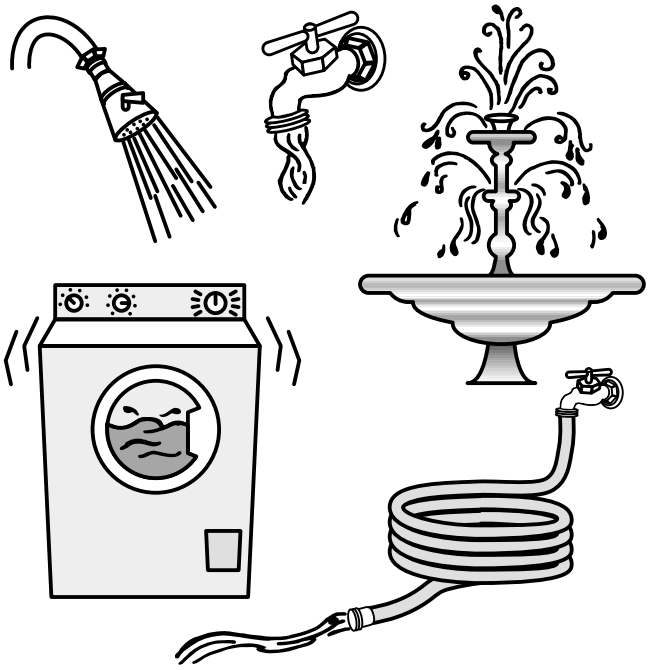
That's a lot of water

Activity Sheet 1

Name _____ **Class period** _____

What you're going to do

You're going to develop methods to estimate the volume of water of water running from a faucet.



How to do it

1. Work with your group. Using the supplies your teacher provides, come up with a way of measuring the flow rate from a faucet or water fountain. Flow rate is a measure of volume over a period of time. For example the flow rate for a water fountain might be 0.75 L per minute. After the group has agreed upon a way of determining flow, write the procedure in your science journal.

2. Test your procedure. First estimate the flow rate for a faucet, water fountain, or other water source. Record your estimates in your journal. Next, follow your group's procedure to determine the flow rate. Calculate the flow rate for each time period three times then average the results.

3. Then determine the flow rate from your water source for 5 seconds, 15 seconds, and 30 seconds. Based on your calculations, what would be the volume of water for a minute, for an hour, for a day, and for a week?

Recording your data

In your science journal, record your group's method for determining flow rate. Then set up a data table that includes the following information:

Water source_____
Estimated flow rate_____
Average volume of water for 5 seconds_____

Average volume of water for 15 seconds_____

Average volume of water for 30 seconds_____

Volume of water
per minute _____
per hour _____
per day _____
per week _____

What did you find out?

What was the most efficient way you devised to accurately measure water flow rates . Explain why you chose this method over the other methods.

Compare your results with those of other groups. What might account for any differences?

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Activity 2

Clean It Up!

What does the wastewater look like that leaves your house? What sort of waste goes in with the water? Would it be okay to put this same wastewater into a stream or lake? How could I clean it myself?

Getting Ready

Overview

Students will devise methods for cleaning a sample of wastewater and evaluate their methods based on criteria developed by the class.

Objectives

After completing this activity, student will be able to—

- explain at least four different methods of water purification
- analyze water purification methods based on criteria such as time, cost, purity of water, and amount of additional waste produced.
- apply laboratory skills in purifying a sample of water

Time Needed

Preparation: Approx. 30 min.
Classroom: Approx. 60 min.

Materials

For the teacher:

- blender
- various waste products you would typically put down the drain and garbage disposal (soap, food scraps, etc.)
- wide range pH paper (pH 2—pH 12)
- conductivity device

Each team of students:

- wire screen
- plastic spoon (for skimming)
- filter paper
- activated charcoal
- sand and gravel
- hot plate
- beaker
- wide-range pH paper (pH 2—pH 12)
- conductivity device

Important Terms

Influent — the wastewater that comes into the wastewater treatment facility.

primary treatment — The first stage of the wastewater treatment process at the facility in which mechanical procedures are used to remove pollutants.

suspended solids — Undissolved waste particles carried by the water.

wastewater treatment facility — A structure with a series of tanks, screens, filters, and other processes used to clean wastewater before it is returned to the environment.

Sewers

Here's How

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the necessary materials.
- Make a copy of Activity Sheet 2 for each student.
- Review the Background information on page 8. Prepare a large bucket with wastewater for students to purify. Be sure there are some large particles that both float and sink (gravel, wood chips, coffee grounds) that can be removed by screening and oil that can be removed by skimming. Garlic powder provides an "interesting" odor for the wastewater.

Engage (Approx. 15 min.)

Start class with a discussion of what might be commonly found in wastewater. Remind students that many storm sewers also bring influent to a treatment plant. List the different kinds of waste material on the board.

Put some clean water into a blender and then add some sample wastes. Blend them together (to simulate the garbage disposal). Students need to be told that there will be no human or animal digestive system waste in the wastewater you are simulating or in the samples they will work with.

Ask students the following series of questions: What do you think the wastewater looks like that leaves our school? What might be the result of putting this wastewater directly into a stream or lake? Would you drink this wastewater? Would you use this wastewater to wash your clothes? Would you use this wastewater to water your lawn? Accept and discuss all answers.

Ask students how they might clean the water. Try not to lead the students into any particular methods of cleaning the water but encourage them to think in terms of removing the waste contaminants in steps or stages depending on the physical characteristics and properties of the contaminants.

Show Video Clip 2 [01:47 to 03:24]. Have students compare their ideas with what they saw in the video. How does the information in the video affect what they think about cleaning wastewater?

Ask students how they might evaluate the purity of the water. Students might suggest observations of color, odor, clarity, and particulate size. Depending upon their prior experience, students might suggest measurements of pH or conductivity. Record student ideas on the board and tell students they will also be evaluating the wastewater for purity after each step in their method. Model pH determination using wide range pH paper (pH 2—pH 12) and conductivity using a conductivity device. As a class, agree on a number of criteria for evaluating water purity.

Show Video Clip 4 [03:19 to 05:07]. Discuss with students why this type of bacterial "cleaning" would be impractical for a classroom activity, but is still a very important step in the "real world."

Video Clip 2
01:47 to 03:24—Treatment plant supervisor Joanne Hart shows Peggy Knapp how skimmers remove suspended matter in wastewater. (1 min. 37 sec.)

Video Clip 4
03:19 to 05:07—Peggy Knapp learns how water treatment plants use bacteria and other microorganisms to remove dissolved pollutants. (1 min. 48 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:55]. Find out what students already know about sewers and wastewater treatment. As a class, discuss the questions posed by Dave Huddleston.
- Under no circumstances should students drink any of the wastewater sample, even after purification. Strongly caution students.
- When reviewing students' plans, you should only reject plans that could cause harm to students. Let them discover themselves what methods work to purify the sample. Some of the most valuable learning can come from a method that does not work.
- Some students may believe that boiling the water will clean the water. As the water boils, the water that is left in the beaker actually becomes more concentrated with contaminants. The water vapor being given off into the air is very pure. Let students experiment with this themselves if they wish. Do not discuss distillation before the exploration part of the activity. If students wish to try to "catch" the water vapor, a watch glass turned upside down on the beaker provides a surface for condensation to occur.
- If time is short, presentations to the class summarizing the steps of the purification method could be done the next day. Water samples should be labeled and saved for students to share with the class.
- If you plan to do Activity 3 with your students, keep the wastewater samples the students have purified.
- If it is appropriate, view the entire *Newton's Apple* video segment on Sewers after completing the activity.

Activity 2

Explore (Approx. 45 min.)

Have students work in small groups. Provide wire screen, plastic spoons, filter paper, activated charcoal, sand and gravel, hot plate, and beakers for students to use. Students are to devise methods for cleaning a wastewater sample and to evaluate their method based on the criteria determined by the class during the Engage section of the activity.

Before students receive their wastewater sample, they should meet together in their groups to discuss and write out a brief purification plan. Students should show this plan to you before they can obtain their wastewater sample. During this planning time, the wastewater should be visible to the students so they can see the condition of the water they will be cleaning.

Students should make initial observations and measurements of their wastewater sample. After each step in their purification method students should make observations and measurements to help them evaluate the effectiveness of that step. Students should analyze and evaluate their plan after each step, instead of waiting until the end to evaluate the entire procedure.

After students complete their purification scheme, they are to make final observations and measurements of their water sample. Student teams should make short presentations to the class showing their water sample, summarizing the steps in their purification method, and reporting on the effectiveness of each step. Students should record the different purification methods and their relative effectiveness (based on class criteria) in their science journals as other teams make their presentations.

Evaluate

1. Were there any steps in your purification plan that you could have left out without changing the final quality of the water sample. Explain and support your answers with observations from your experiment.

2. How would your methods for cleaning a wastewater sample change if you had to clean three million liters of water in less than five hours as inexpensively as possible.

3. Based on the information you recorded in your journal from the team presentations, devise a step-by-step method for cleaning a wastewater sample in the laboratory that would result in the largest amount of clean water. Would this method be practical to use for a wastewater treatment plant? Explain.

Try This

Arrange a trip to your local wastewater treatment plant. Take along a sample container to obtain a sample of the wastewater after it has gone through all the purification steps. Obtain samples of water from local streams or lakes. Label each sample. Set the samples in a place where they will not be disturbed for several hours. What happens to the suspended solids in the water samples? Share your samples of water with the class. Discuss the water quality from these sources.

Obtain a large one-liter beaker from your teacher and fill it with tap water. Place the beaker of water on a hot plate and heat gently until all the water has evaporated. Inspect the beaker and comment on the dissolved solids in your tap water. Try this activity with samples of water from many different sources. Share your results with the class.

Clean it up!

Activity Sheet 2

Name _____ Class Period

What ~~you're going~~ to do

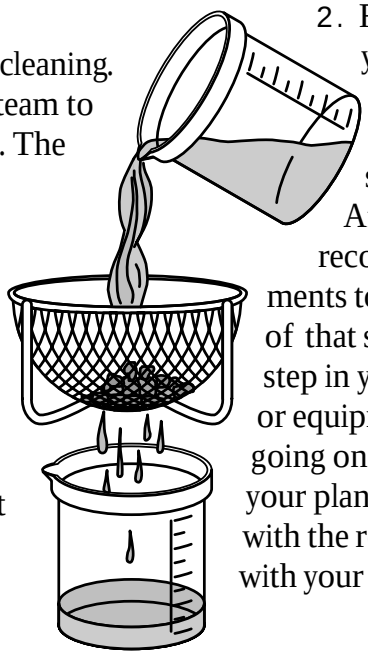
You're going to develop and follow a plan for cleaning a sample of wastewater. After each step in your plan you will make observations and measurements to determine how effective that step was in cleaning the water sample.

How to do it

Part 1: Develop a Plan

1. Examine the wastewater you will be cleaning. Meet with the other members of your team to discuss and develop a purification plan. The plan should show:
   - the order of steps
   - the target waste for each step
   - the materials needed
   - the procedure to follow for each step

You may want to use the guide below to set up your plan. After you develop your plan, have your teacher approve it and obtain your wastewater sample.



Part 2: Cleaning the Sample of Wastewater

2. Follow the plan you developed to clean your sample of wastewater. Remember to make initial observations and measurements of your wastewater sample before starting the first step. After each step in your purification plan, record your observations and measurements to help you determine the effectiveness of that step. After your team completes each step in your procedure, clean up any materials or equipment you will not be using again before going on to the next step. After you complete your plan, save your purified sample to share with the rest of the class. Label the clean sample with your team name.

Recording your data

Record your observations and measurements of your wastewater sample after each step in your plan. You may want to record the amount of time it takes to complete each step of your purification plan. Set up a table in your journal.

Step #	Target Waste to Remove	Wastewater Observations	Wastewater Measurements	Time

What did you find out?

Your team should prepare a short presentation to be shared with the class. Summarize the steps you took to clean your wastewater. Report on the effectiveness of each step in cleaning the wastewater during your presentation. Show the wastewater sample you purified.

List at least five ways your clean sample of wastewater could be used in your home. Would you use it? Why or why not?

If you were given a new sample of wastewater to clean tomorrow, what steps in your purification method would you change and why?

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Activity 3

That's Enough!

Where does the water come from that we drink? How clean is the water we drink? What types of waste are the most difficult to remove from wastewater? What determines if a substance in the water is harmful? How much of a substance needs to be in water before it is harmful?

Getting Ready

Overview

Students will measure concentrations in parts per million, parts per thousand, and parts per hundred. Students will investigate the effect of contaminants in water on living organisms and at what concentration the contaminant is lethal to an organism.

Objectives

After completing this activity, students will be able to—

- explain concentration in parts per million, parts per thousand, and parts per hundred
- devise and conduct an experiment to determine the concentration level at which a contaminant in wastewater will affect an organism.
- analyze data to determine categories of contaminants and the lowest concentrations that affect an organism

Time Needed

Preparation: Approx. 60 minutes
Classroom: Approx. 110 minutes

Materials

For the teacher:

- 2 large test tubes (30 - 50 mL volume)
- container that will hold 25L (6.625 gallons) of water (small to medium-sized aquarium or other clear glass container)
- 10mL graduated cylinder
- 1 micro-tip beral pipet
- blue food coloring
- 1 piece of filter paper and a funnel

For each student:

- 1 micro-tip beral pipet
- 1 10mL graduated cylinder
- 1 small beaker or paper cup to hold tap water
- brine shrimp

A variety of household substances commonly put down the drain that are soluble in water and not removed in primary wastewater treatment (vinegar, ammonia, hand soap, dish soap, shampoo, cleaning products, detergents) Each team will be investigating a different substance.

For each team of students:

- several medium-to-large test tubes with a volume capacity of at least 30mL
- jumbo-tip beral pipet
- micro-tip beral pipet
- 10mL graduated cylinder
- 30 to 60 brine shrimp in a small beaker or cup

Important Terms

advanced treatment — A level of treatment which removes additional contaminants that have not been removed by secondary treatment.

dissolved contaminants — Waste in water that is soluble and cannot be removed by mechanical procedures.

effluent — Water that flows from a treatment facility after the wastewater has been treated.

material safety data sheet (MSDS) — Information on reactivity, hazardous components, physical data, and health hazard information for chemicals and consumer products.

secondary treatment — The second stage in wastewater treatment in which microorganisms consume the organic part of the waste.

Sewers

Video Clip 3
05:39 to 06:11—Peggy Knapp examines the cleaned water that is released from the treatment plant. (32 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:55]. Find out what students already know about sewers and wastewater treatment. As a class, discuss the questions posed by Dave Huddleston.
- If you do not have 10 mL graduated cylinders available for each student use a small test tube and measure exactly 1 mL of water into the test tube and using a permanent marker make a mark on the outside of the tube at the bottom of the meniscus. Make a class set of these graduated test tubes.
- Ask students if they should empty the graduated cylinder each time or if they should measure from 0 mL—1 mL, 1 mL—2 mL, and 2 mL—3 mL. Which method is better? Why?
- When adding the one drop of blue food coloring emphasize to students your technique in adding this drop. Hold the beral straight up and down or the drop size will vary significantly.
- Use a conductivity device to show another method to "measure" concentration of dissolved electrolytes in solution. Set up containers with volumes of 100 drops, 1000 drops, and 1,000,000 drops and add a saturated solution of sodium chloride drop by drop. The light bulb will glow with different intensities, depending upon the concentration of the salt.
- Live brine shrimp are available in most pet stores that sell fish. They store well in the refrigerator overnight but should then be put into a large container of 1.03 % salt water with an aerator (they will live for about 48 hours without an aerator). Brine shrimp can be fed a very small amount of dry yeast. Brine shrimp can live about 2 weeks under ideal conditions.
- Brine shrimp can be easily transferred into test tubes by using large stem plastic berals with the narrow tip cut off.
- If students completed Sewers Activity 2, have them set up one additional test tube using this purified water sample with the brine shrimp.
- If it is appropriate, view the entire *Newton's Apple* video segment on Sewers after completing this activity.

Here's How

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the necessary materials.
- Make copies of Activity Sheet 3 for each student.
- Review the information in the Background on page 8.
- Prepare a large container for the brine shrimp.

Engage (Approx. 30 min.)

Distribute a graduated cylinder, a small beaker or paper cup half filled with tap water, and a micro-tip plastic beral to each student. Instruct students to accurately determine how many drops are in 1.0 mL. Have them replicate the measurement at least three times. Students should then average their three values to determine the average number of drops per mL. Circulate through the classroom and have students report their average number of drops per mL. Record these averages and calculate the class average (approximately 40 drops per mL).

Ask students how they would calculate the volume of 100 drops? 1,000 drops? 1,000,000 drops? (Some students might suggest counting out 100 drops but few will suggest counting out 1,000 or 1,000,000 drops.)

Measure out the volume of 100 drops (2.5mL), 1,000 drops (25mL), and 1,000,000 drops (25L). Show students these volumes of water and discuss the differences in these volumes. Using the micro-tip beral, add **exactly one drop** of blue food coloring to the measured volume of 100 drops of water, 1,000 drops of water, and 1,000,000 drops of water. Ask students how you could express each of these as a fraction. [One part per hundred (1 pph), one part per thousand (1 ppt), and one part per million (1 ppm).]

Ask students the following questions: Why doesn't the color have the same intensity in each container? (different concentrations) Is there any blue "contaminant" in the 1,000,000 drop volume? (yes) Why can't we see the color? (too diluted to see with human eye) Is the human eye an accurate measurement device for concentration? (no) Are all contaminants in water colored? (no) Would blue food coloring be removed from wastewater by filtering? (no)

Set up a piece of filter paper in a funnel and demonstrate that the food coloring is dissolved and not removed by filtering.

Show Video Clip 3 [05:39 to 06:11]. Discuss the kinds of pollutants that are still in the water when it is released. How dangerous are these materials? (It depends, in part, on their concentration.)

Ask students what might happen to a stream that has contaminants in it. (The contaminants might have a harmful effect on plant and animal life.) What might happen to the bacteria in the secondary treatment tanks if there are toxic chemicals dissolved in the water? (The bacteria could be killed.)

Explain to students that they are going to investigate the effect of some common contaminants on living organisms and determine at what concentration organisms are affected by different contaminants.

Activity 3

Explore (Approx. 80 min. over two days)

Students should work in small groups. Provide each group with test tubes, a micro-tip beral, tap water, 10-mL graduated cylinder, hand lens, and common household contaminants that are soluble in water and not removed during primary treatment. Students are to devise an experiment to determine what contaminants affect brine shrimp and at what minimum concentration the effects are life threatening.

Before students can experiment with the brine shrimp they must meet together with their group to discuss and write out an experimental procedure that clearly shows what contaminant is to be used and how the concentrations will be determined. A control tube must be included. The experimental procedure is then shared and discussed with the teacher before groups can obtain their brine shrimp.

Be sure to emphasize that students must set up a range of concentrations and that the brine shrimp must be allowed sufficient response time. The tubes will be set up one day and initial observations taken. Final observations will be taken the following day. Students will need to think about the most efficient way to set up their experiment to obtain meaningful results. They will be allowed a maximum of 30 test tubes.

After students complete their experiments and determine the lowest concentration at which a contaminant starts to affect the brine shrimp they should prepare a short presentation to the class to share their results. Students should record the summary information each research team shares with the class in their science journals. Students will then analyze the class data to see if there are any similarities in the contaminants and to determine the lowest concentrations at which the brine shrimp were affected. Students can then devise further experiments to test any similarities observed and then develop a working hypothesis of organism response to different kinds of contaminants.

Evaluate

1. Analyze the data you recorded in your science journal from the team presentations to see if there are any similarities in the contaminants. Is there any similarity in the lowest concentrations of the contaminants that affected the brine shrimp? Write a hypothesis for organism response to different categories of contaminants and devise an experimental procedure to test your hypothesis. (Answers will vary. Student responses should reflect an understanding of concentrations of contaminants and their effect on organisms.)

2. You are shopping with Aunt Matilda at the grocery store for cleaning products. She knows about your study of wastewater and asks your opinion about which of the following two products she should buy to clean the toilets at home.

Product Name:	*Easy Clean*	*Bright and Shiny*
Cost per Liter:	$2.56	$3.25
Ingredients:	water	sodium bicarbonate
	sodium hydroxide	citric acid
	FD&C blue #2	FD&C red #33
		FD&C blue #5

Explain clearly how you would determine which product to advise your Aunt to purchase. What information would you need to support your decision? Where and how might you obtain this information? What things should you consider when determining what products to purchase? Which of these is most important? Why? (Answers should reflect a synthesis of the knowledge gained while doing this activity. Scientific methods should be applied to the problem.)

Try This

Make your own container showing concentrations of parts per hundred, parts per thousand, or parts per million. You might use a small solid and color some of the "pieces" different colors to show different concentrations. Share your model with the class.

Using the Internet, look up material safety data sheets (MSDS) for some of the common chemicals and products found in your home. Check the label on products to find out the chemical names of the ingredients. List the chemicals and any hazards associated with them for at least one product and share this information with your class. Be sure to report on any toxic concentration levels reported in the MSDS.

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that's enough

Activity Sheet 3

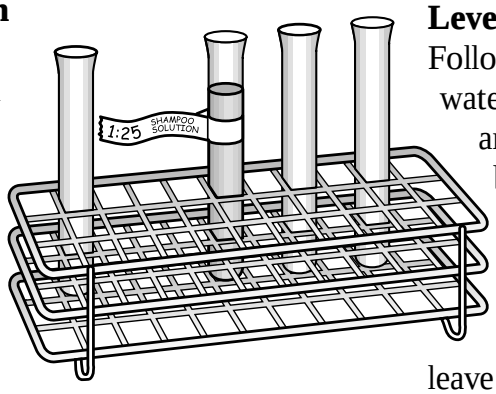
Name _____ **Class Period** _____

What you're going to do

You're going to determine the lowest concentration of a contaminant in water that affects a living organism (brine shrimp).

How to do it

Part I: Develop a Plan



Meet with the other members of your team and determine which household product you would like to use in your investigation. Discuss how you will measure the concentration of the contaminant in water. Write out a short procedure to determine the lowest concentration of the contaminant in water that will affect brine shrimp. Keep in mind that brine shrimp need adequate response time (hours) to react to a contaminant once it is introduced into the water. Be sure to include a control. You may want to use the guide below to help you devise your plan.

Volume Volume

Test Tube Procedure Water Contaminant Concentration

Have your final plan approved by your teacher and obtain your brine shrimp.

Part II: Determination of the Concentration Level Which Affects Brine Shrimp

Follow your plan. You may want to measure the water into each test tube, add the contaminant and mix completely before introducing the brine shrimp, so you do not squish the brine shrimp during mixing. Label each test tube. Be sure to record an initial set of observations after introduction of the brine shrimp and a second set of observations before you leave class for the day. The test tubes containing your brine shrimp and contaminants should be placed in a safe place and labeled with your team name. The next day, record your observations of the brine shrimp.

Recording your data

Be sure to record your measurements and observations for each different concentration you test. You will make observations at different times so plan your data table accordingly. A sample table for organizing your data and observations is shown below.

Test Tube Contaminant Concentration Time Observations

What did you find out?

Your team should prepare a short presentation to be shared with the class summarizing your experiment. Report the lowest concentration of contaminant that affected the brine shrimp.

When you use a cleaning product in your home, how could you determine if the concentration of this product in the wastewater was great enough to affect living organisms?

After completing your investigation explain what changes you would make if you were to investigate the effect of another contaminant?

Compare your results with other groups. What might account for any differences?

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River of Grass

Why are people so concerned about the Everglades? Why do people want to protect wetlands? Is it possible to balance the development of towns and cities with the habitats around them? How can we determine when a wetland is in danger?

Themes and Concepts

- systems
- models
- constancy and change
- wetlands
- ecology and environmental science

National Science Education Standards

Content Standard A: Students should develop abilities necessary to do scientific inquiry.
Content Standard C: Students should develop an understanding of populations and ecosystems.
Content Standard C: Students should develop an understanding of diversity and adaptations of organisms.
Content Standard F: Students should develop an understanding of populations, resources, and environments.

Activities

1. ***Spinning the Web of Life—Approx. 10 min. prep; two class periods***

Students design a model "web of life" for the various organisms found in a wetland environment. They first predict, then manipulate the model to see how changes in water level might affect the various components in the ecosystem.

2. ***Sea Salts—Approx. 15 min. prep; 45 min. class time***

Students build hydrometers and use them to calculate the differences in salt content in three "unknown" water samples. Based on their measurements, they will predict what happens when water samples of differing salinities mix and discover how changes in the salinity can have an effect on the entire ecosystem.

3. ***Go With the Flow— approx. 10 min. prep; 45 min. class time***

Students develop a hypothetical water budget for south Florida and see how factors such as precipitation, evaporation, and diversion of water affect the availability of water in the system.

More Information

Internet

Newton's Apple
http://www.ktca.org/newtons
(The official *Newton's Apple* web site with a searchable database of science activities on many different subjects.)

Everglades Home Page
http://everglades.ycg.ORG/index.htm
(The home page for the Everglades site contains a description of the Everglades and explores its history and make-up.)

FIU—Everglades Interactive Learning Case Study
Florida International University
http://www.eng.fiu.edu/evrglads/
(This site is a great resource to learn what plants and animals live in the Everglades. The site also has a slide show, photos, and lots of links to other sites about the Everglades and wetlands.)

Everglades Ecosystem—Everglades National Park
http://www.nps.gov/ever/eco/index.htm
(This site has profiles on the Everglades' animals, plants, and habitat.)

Internet Search Words

Everglades
river of grass
wetlands
national parks
ecosystems

Everglades

Background

On the southern tip of Florida, just west of Miami, is the 1.5-million-acre Everglades National Park, a mosquito and alligator-filled wetland that a writer once described as the "liquid heart of Florida." A person taking a quick drive through the Everglades might be disappointed, for there are no mountains, waterfalls, rock formations, or even hills. You might see pink flamingos (real ones!) or other colorful birds, but mostly what you'll see is a flat vista of sawgrass dotted by small islands of trees.

The Everglades sits at the edge of the tropical and temperate zones, making it the only subtropical wilderness area in the U.S. The freshwater moving through the Everglades is a few inches to a few feet deep, and flows very slowly at a rate of between 100 and 200 meters per day. All along its edges, salt water mixes with freshwater, creating an unusually rich, briny soup.

The real treasure of the Everglades is its biodiversity. It is a patchwork of habitats, in some places perfect for flocks of flamingos, in other places perfect for alligators, in yet other areas just right for the rare panther. So unique are the habitats within the Everglades that they are home to 56 plants and animals declared endangered or threatened under the federal Endangered Species Act.

Until human development began to intrude on it in the early 1900s, the Everglades was really a wet plain 40 miles wide and 100 miles long. But dikes and drainage ditches were built in increasing numbers to control seasonal flooding. Like most swamps and wetlands, the Everglades was seen as a nuisance, not a treasure.

The destruction of the Everglades really began in 1947, the same year it was declared a national park. Congress directed the Army Corps of Engineers to build a massive flood control project in south Florida, and over the next 25 years some 1,400 miles of canals, levees, dikes and pump stations were built that diverted much of the fresh water out of the Everglades. The 102-mile long Kissimmee River that flowed into the Everglades was converted into a 56-mile canal, and 1,100 square miles of critical bog lands at the north end of the park were drained and converted into sugar cane farms.

In the last couple of decades, scientists, environmentalists and government officials have realized that the massive effort to control the Everglades had so disrupted the complex natural workings of the marsh that it was dying. The problem was so bad that "conservation" wasn't enough, so an extensive "restoration" program was launched. That effort, which will eventually cost billions of dollars, is underway but the scientific problems are daunting.

Given that millions of people live in the region and so much land around the Everglades has been developed, it is impossible to simply tear out all of the flood control canals and dikes. What scientists are trying to do is find a way to regulate water flow in the Everglades so the natural cycles work as they did in the past. If it works, the recovery of the Everglades will mean creating at 18,000-square-mile ecosystem that blends modern society with an ancient swamp.

If it fails, the only pink flamingos in the region might be the plastic kind that you stick in your front yard.

Books and Articles

Culotta, Elizabeth. "Bringing Back the Everglades," *Science*, June 23, 1995, p. 1688.

Davis, Steven M. and Ogden, John C. *Everglades: The Ecosystem and Its Restoration*. Boca Raton, FL: Saint Lucie Press, 1994.

George, Jean Craighead. *Everglades*. New York, NY: Harper Collins Publishers, 1995.

Lisowski, Marylin and Williams, Robert A. *Wetlands*. New York, NY: Franklin Watts, 1997.

Rood, Ronald N. *Wetlands*. New York, NY: Harper Collins Publishers, 1994.

Tiner, Ralph W. *In Search of Swampland: A Wetland Sourcebook*. Piscataway, NJ: Rutgers University Press, 1998.

Video

Wood Stork, Barometer of the Everglades. Stanford, CT: Vestron Video, National Audubon Video, 1987.

Video & Stills

Video Segments

Introduction

00:00 to 00:43—Sun Me Chomet thinks about wetlands and comes up with some interesting questions for discussion. (43 sec.)

Video Clip 1

00:56 to 03:31—Field reporter Peggy Knapp shows some of the plants and animals that inhabit Florida's great "River of Grass." (2 min. 35 sec.)

Video Clip 2

03:30 to 05:13—Peggy Knapp and Thomas Bancroft of the National Audubon Society explore waterways of the Everglades to find out why they're drying up. (1 min. 43 sec.)

Video Clip 3

05:14 to 06:56—Peggy Knapp and Thomas Bancroft navigate a boat through a mangrove estuary where freshwater mixes with salt water. (1 min. 42 sec.)

Video Clip 4

06:57 to 10:14—Peggy Knapp learns how changes to the Everglades threaten many of the bird species that live there. (3 min. 17 sec.)

Additional Resources

Button A

Slide Show: Photos of southern Florida taken from space.

Button B

Slide Show: Two maps of southern Florida showing the flow of water from Lake Okeechobee to the southern tip of the state.

Button C

Slide Show: Cross-section and photos detail three distinct habitats in the Everglades.

Button D

Slide Show: Photos of animals that are commonly found in the Everglades.

Unit Assessment Answer Key

The Unit Assessment on the following page covers the basic concepts presented in the video segment and the background on the Unit Theme section in this guide. The assessment does not require completing all of the activities. The Unit Assessment may be used as a pre- or post-test. However, students should view the complete *Newton's Apple* video before doing this assessment. There is additional assessment at the end of each activity.

Think about it

1. The Army Corps of Engineers built a series of canals that diverted the flow of water away from the Everglades. The idea was to control flooding and to provide water for irrigation and for growing urban areas. The result is that the Everglades ecosystem has been changed and in some areas damaged beyond repair.
2. The natural state of the Everglades is a wetland that is filled with sawgrass. Freshwater from Lake Okeechobee in central Florida flowed southward across millions of acres of land to the Gulf of Mexico. It wasn't a river and it wasn't grasslands—it was a river of grass.
3. Some people believe that the more people know and understand about the fragile ecosystem of the Everglades, the more likely those people are to help reserve and restore the area. Before you can solve a problem, you must understand the nature of the problem.
4. The plant and aquatic life that supports the birds and much of the ecosystem of the mangrove estuary requires a certain level of salinity—too much salt and the aquatic life dies. As the supply of freshwater to the mangrove estuary has been decreased, the salinity of the water has increased, killing off the aquatic life and the birds that feed on it.
5. When the Everglades were in a natural state, the population of wading birds was enormous. As freshwater was diverted from the Everglades, the ecosystem was altered. The number of wading birds decreased drastically. The number and health of the wading bird population can be directly tied to the overall condition of the Everglades.

What would you say?

6. d 7. a 8. b 9. c 10. b

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Unit Assessment

What do you know about the Everglades?

Write the answers to these questions in your journal or on a separate piece of paper.

Think about it

1. Explain what the Army Corps of Engineers did to the Everglades.

2. Why is the Everglades called the "River of Grass"?

3. Why do some people think that education is the key to saving the Everglades?

4. Why is the balance of salt water and freshwater so important in the mangrove estuary region of the Everglades?

5. How does the study of wading birds reflect the health of the Everglades as a whole?

What would you say?

6. What is the main reason the Everglades are "shrinking"?
   a. flooding
   b. drought
   c. tidal patterns
   d. human factors

7. The Everglades are located _____
   a. in southern Florida.
   b. in northern Florida.
   c. in the Florida Keys
   d. throughout the entire state of Florida.

8. The water in the Everglades _____
   a. is entirely salt water.
   b. flows slowly through the wetlands.
   c. is entirely freshwater.
   d. comes entirely from precipitation.

9. An estuary is _____
   a. a point of land surrounded by water.
   b. another word for "river."
   c. where freshwater and salt water flow together.
   d. a type of salt water lake.

10. The plant and animal life in the Everglades _____
    a. is completely aquatic.
    b. is very diverse.
    c. is very limited.
    d. lives mostly in the northern portion.

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Activity 1

Spinning the Web of Life

What is a wetland and why are wetlands important? What types of animals and plants live in a wetland environment? What makes the ecosystem of the Everglades unique? What happens to animal and plant life when the water level in a wetland changes?

Getting Ready

Overview

Students design a model "web of life" for the various organisms found in a wetland environment. They first predict, then manipulate the model to see how changes in water level might affect the various components in the ecosystem.

Objectives

After completing this activity, students will be able to—

- describe how different organisms cause changes to the environment in which they live
- demonstrate how humans can cause changes to the environment that are detrimental to other organisms
- explain how the number of organisms an ecosystem can support depends on the resources available including abiotic factors such as water

Time Needed

Preparation: Approx. 10 min.
Classroom: Approx. 2 class periods

Materials

For the teacher:

- current map of Florida
- large ball of twine or yarn

For each team of students:

- large (5x7) blank index card for each student
- large ball of twine or wool
- range of reference materials from which students can get information about the various life forms found in a wetland environment.

Important Terms

abiotic — Non-living elements of an ecosystem such as water, sun, and dirt.

ecosystem — A community including all the component organisms together with the abiotic environment, forming an interacting system.

living consumer — An organism that eats another organism to obtain energy.

producer — An organism able to synthesize organic material from inorganic sources.

savanna — An area of continuous grassland with occasional trees or shrubs.

sub-tropic — Region which has distinct summer and winter seasons yet is warmer than the temperate zone.

wetland — A swampy, marshy area where the water table is at or near the surface for most of the year.

Everglades

Here's How

Video Clip 1
00:56 to 03:31—Field reporter Peggy Knapp shows some of the plants and animals that inhabit Florida's great "River of Grass." (2 min. 35 sec.)

Video Clip 2
03:30 to 05:13—Peggy Knapp and Thomas Bancroft of the National Audubon Society explore waterways of the Everglades to find out why they're drying up. (1 min. 43 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:43]. Find out what students already know about the Everglades. As a class, discuss the questions posed by Sun Me Chomet.
- Instead of using the classroom, construct the web in the gym or outside in a large open space.
- You can find satellite images of the Everglades and south Florida at Resource Button A on the CD-ROM.
- Students should answer specific questions in their research such as what their organism eats, what eats it, and what type of environment is it best suited to.
- If it is appropriate, you may wish to view the entire *Newton's Apple* segment on the Everglades after completing this activity.

Preparation
- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the necessary materials for the teacher demo and the student experiments.
- Make a copy of Activity Sheet 1 for each student.
- Review the Background information on page 24.

Engage (Approx. 20 min.)

Play Video Clip 1 [00:56 to 03:31] and pause it after the park ranger says "And everything's cycled around what? Water. Okay!" Ask students if they have ever visited a wetland area. What are some of the things that make this type of environment unique? Do wetlands serve any purpose other than a home for local wildlife? Get a few answers, and explain that they are going to get a close-up look at one of our nation's most important wetlands.

Play the rest of Video Clip 1. Have the students look at the screen. Then move the slider to the left a bit to the previous dried-out habitat. Ask them to make some quick observations about the local environment. Are there any clues to suggest that these environments go through some significant changes? (The first habitat is lush, wet, and green. The second habitat is dry, but sea shells suggest that it was once covered with water.)

Move the slider back to the left to the map showing the original extent of the Everglades [02:42]. Then hold up a current map of Florida showing the major population centers. Ask students if they can think of any reason why water in the "river of grass" has been cut off and controlled. (Development in the cities of Miami, West Palm Beach and other urban centers require freshwater for the people who live and visit there. Farmers need the freshwater for agricultural products.) Ask them if they can think of any other situations in the world where the needs of people caused a local environment to be placed under stress? (rain forests, old growth forests)

Play Video Clip 2 in its entirety [03:30 to 05:13]. Explain that the Everglades and all wetlands are important ecosystems. Not only do they hold water, but they provide a habitat for many different animal and plant species, including amphibians, reptiles, insects, birds, fish and mammals. Tell students their mission is to construct a model "web of life" for a typical wetland, and then see what will happen when the water is taken away.

Activity 1

Explore (Approx. 25 min.)

Have students work in groups of four. Begin by having each group make a list of the various organisms and factors which come into play in a typical wetland environment. Make sure that they don't just include living things, but abiotic factors as well, such as water, soil, minerals, nutrients, and the Sun, etc.

In the last five minutes of class, have each group read their list and compile a master list. For homework, have each student select one item from the list to research how it fits into a wetland environment. Give each student a large index card on which he or she will record this information. Explain that during the next class, they are going to use this data to construct a model "web of life" for a typical wetland environment.

In the second class session, have the students clear out all the desks and sit in a large circle holding their index cards. Each student will assume the role of the organism or abiotic factor on their card. Have each student read their card in turn, then, using the string, connect to another organism or factor upon which they depend. For example; fish eat algae, birds eat fish, birds live in trees, trees use nutrients in soil, bacteria release nutrients into soil, etc.

After completing the first web, give the students Activity Sheet 1. Explain that a local community nearby needs to divert water from the wetland for drinking purposes. When this happens, there is a chance the wetland will go dry. Have the students draw another web on the activity sheet assuming that there is very little water available in the wetland. Based on the model they created, have them identify the types of organisms that would be most greatly affected by loss of water in the wetland environment.

Evaluate

1. How does the "web of life" game played by the class relate to the situation in the Florida Everglades? (It is a direct parallel. Water is diverted for use in communities in south Florida and for farm land in the central region. As a result, millions of acres of wetland habitat have been destroyed causing the loss of many animal and plant species.)

2. In the "web of life" many unpredicted environmental problems result because connections are intertwined. Sometimes a problem will happen at one end of the web because of an event that appears to be totally unrelated. Can you use this web model to predict such a problem? (Answers will vary.) An example might be that the lower water levels will allow emergent grasses to encroach into the open-water areas, allowing terrestrial predators like skunks better access to waterfowl nests, decreasing the number of eggs, therefore lowering the total population.)

3. When developers want to make a major change to a local natural environment, they often have to file an environmental impact statement that identifies all of the positive and negative effects of the project. How might this web of life activity be used in such an impact statement. (By identifying all the species and their needs, the web can be used to model the future conditions after the development has taken place.)

Try This

Create your own wetland terrarium by getting a large fish tank and modeling it after a natural wetland. Begin by researching the local environment to see what plant and animal species inhabit the area. Include representative species in your terrarium. Do not take anything from the wild for your terrarium.

Many of the species of plants and animals that inhabit wetlands are considered to be either endangered or threatened. Research your local area and see if there are any endangered or threatened species in wetlands near your home. If so, see what is being done to protect them.

spinning the web of life

Activity Sheet 1

Name _____ **Class Period** _____

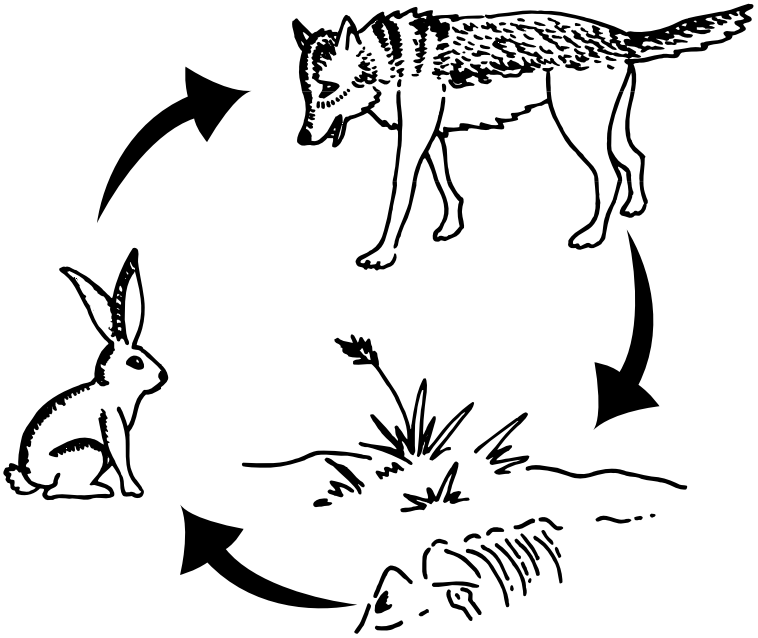
What you're going to do

Based on the web of life you and your classmates create, you are going to predict what will happen should the water suddenly be diverted.

How to do it

Day 1

Work with your group. Choose a wetland. It might be a local wetland or a wetland like the Everglades. Listing all the biotic and abiotic factors in your wetland. Each member of the group should choose one or two factors from the list and do additional research. Come up with some specific questions to answer such as: What does it eat? What eats it? What is an ideal environment? What environmental factors could be harmful? Write this information on an index card and bring it to class.



Day 2

After you have formed the large web with your class, draw a diagram of the web of connections that you and your classmates made.

Next, with your group, draw a second web using the same factors. This time, however, show which connections would be broken if the water were to be removed from the system.

Recording your data

In your science journal, draw a diagram of the web of life you constructed with the entire class. Label each of the biotic and abiotic factors and draw lines connecting them with other factors.

Make a diagram of the web your group created that shows how a lack of water can affect an ecosystem.

What Did You Find Out?

What did you find most interesting about the large web of life your class created?

Were there any relationships between factors that surprised you? Explain.

Compare the "waterless" web your group created with the webs from other groups. How were they similar and different? Did some groups see more relationships than others?

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Activity 2

Sea Salts

What happens when freshwater from the Everglades meets salt water in the ocean? How does the salt concentration of the water affect a marine ecosystem? How does development upstream change the salinity of the Everglades downstream? Why would salt concentration affect the bird population?

Getting Ready

Overview

Students discover how changes in the salinity of the Florida Bay estuary can have an effect on the entire ecosystem.

To learn how to measure salinity, they build their own hydrometers and use them to calculate the differences in salt content in three "unknown" water samples. Based on their measurements, they will predict what happens when water samples of differing salinities mix.

Objectives

After completing this activity, students will be able to—

- use a hydrometer to measure the salinity differences in water samples
- predict what happens when waters of two different salinities mix.
- describe how changes in the salinity of a marine ecosystem affect the overall population balance.

Time Needed

Preparation: Approx. 15 min.
Classroom: Approx. 45 min.

Materials

For the teacher:

- 2 raw eggs in the shell (wash the shells well with soap and water before the activity)
- 16-oz clear glass of fresh water
- 16-oz clear glass of extremely salty water
- hydrometer
- 500-ml graduated cylinder
- 16-oz plastic cup filled with fresh water
- 16-oz plastic cup filled with 1% salt water
- 16-oz plastic cup filled with 2% salt water
- 16-oz plastic cup filled with 3% salt water

For each team of students:

- 4 disposable plastic drinking straws (clear if possible)
- small lump of waterproof modeling clay
- cup of dry sand
- waterproof marker or pen
- 3 plastic cups (16-oz) labeled "A", "B", and "C"

Important Terms

brackish water — Water that has a salt concentration in between freshwater and the concentration of sea water, which is 3.6%.

density — The mass of matter compared to its volume (D = M/V)

estuary — a body of water in which freshwater from the land mixes with salt water from the ocean.

hydrometer — A device for measuring the density of a liquid.

interface — An area where two different things interact. In an ecosystem, it's where two different environments come together, such as where freshwater meets salt water in an estuary.

salinity — A measure of how salty water is. It is usually given as a percent or in parts per thousand. Sea water has a salinity of 3.6% or 36 parts per thousand (ppt).

Everglades

Here's How

Video Clip 3
05:14 to 06:56—Peggy Knapp and Thomas Bancroft navigate a boat through a mangrove estuary where freshwater mixes with salt water. (1 min. 42 sec.)

Preparation

- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Gather the necessary materials for the teacher demo and the student experiments.
- Mix up 3 samples of salt water at concentrations of 10, 20, 30 ppt (1%, 2%, 3%). Place these in 3 labeled 16-oz tall plastic cups. Label each with the salt concentration. Use the standard hydrometer to test each before class to make sure the concentrations are accurate. These will serve as the "standards" upon which the students will calibrate their hydrometers.
- Mix 3 "unknown" samples of salt water which the students will try to determine the salinity. Label these "A", "B", and "C". Test the unknowns with the hydrometer beforehand and record their concentrations for your records.
- Make a copy of Activity Sheet 2 for each students.
- Review the Background information on page 24.

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:43]. Find out what students already know about the Everglades. As a class, discuss the questions posed by Sun Me Chomet.

- Make certain you mix all the salt water solutions before class and then test them again before the students arrive to verify that their salinity remains constant. To obtain the most accurate readings on the student hydrometers, use tall narrow glasses for the water.

- As an alternative to glasses, you can use 500-mL graduated cylinders. You can mix your "Standard" solutions and store them in 1 gallon plastic jugs. Students can then dispense them into individual plastic cups so each group can have their own set of standards. This will reduce some of the waiting time for students who need to calibrate their hydrometers.

- A good source of inexpensive commercial hydrometers is pet stores, where they are sold for use with saltwater aquariums.

- If it is appropriate, you may wish to view the entire *Newton's Apple* segment on the Everglades after completing this activity.

Engage (Approx. 10 min.)

Ask a student volunteer to come forward to assist with a demonstration. Give the student two raw eggs. Have the student place one egg in the glass with the freshwater and place the second in the glass with the salt water. Ask the other students to observe what happens. (The egg in the salt water will float while the one in the freshwater will sink.) Assuming the eggs are the same, ask students to explain why they think there is a difference in the two eggs. After getting a few ideas, have the student volunteer taste the two water samples by dipping in a finger and touching it to his or her tongue. Explain that salt water is much denser than freshwater, which is why the egg floats. When fresh water and salt water meet in an estuary, not only do these differences in density cause immediate problems, but future problems happen too. Play Video Clip 3 [05:14 to 6:56]. Pause the clip after Peggy says "…is critical to the survival of many species, including fish and the wading birds that feed on them." Ask students how changes in the salt concentration might affect the organisms living in the estuary. Get a few ideas.

Resume the video clip and pause again when Peggy asks, "Because there's not as much freshwater coming down, it's broken up the food chain?" Explain that one reason the food chain in Florida Bay is getting disrupted is because many organisms at the lower end of the food chain can only tolerate low salt concentrations. As the freshwater is cut off, the salinity of the bay goes up and these organisms can no longer survive. Continue the video to the end of the clip.

Discuss some of the many factors that help to control the salinity of an estuary—tides, storms, and floods all change the salinity at different points in daily and seasonal hydrologic cycles. While many organisms can tolerate these short-term changes, it's the long-term changes that really have the most drastic effects. To monitor changes in salinity, marine ecologists use a device called a hydrometer. A hydrometer indirectly measures the salt concentration of water by measuring its density.

At this point, use the standard hydrometer to show students how it works in the different "standard" water samples. Explain that their mission is to build their own simple hydrometer and use it to calculate the salinity of three unknown samples. Based on their calculations, they will then be asked to predict what happens when waters of different salinities mix.

Activity 2

Explore (Approx. 35 min.)

Have students work in groups of four. Explain that they are going to build a set of "standard" hydrometers and then use them to calculate the salinity of three "unknown" samples. Each group will be given four drinking straws, a lump of modeling clay, a cup of sand, four pieces of masking tape and a waterproof pen. Each student in the group will build one of the standard hydrometers according to the directions on the activity sheet. Group members will then share the hydrometers to determine the salinity of the four "unknown" water samples. Direct their attention to Activity Sheet 2, "Sea Salts."

Before beginning, demonstrate how to construct one of the hydrometers and how to calibrate it against one of the four "standard" solutions. Make sure that the students label each hydrometer with the correct salinity reading.

Evaluate

1. Based on your observations, what's the relationship between the salinity of the water and its density? (The greater the salt concentration, the more dense the water is.)

2. Within an estuary, the freshwater enters from a stream or a river flowing from the land. Based on what you determined about the density of salt water, how would the salinity of an estuary change as you go from the surface to the bottom? (In general, estuaries have a "freshwater lens" on top and a "saltwater wedge" on the bottom. The deeper you go, the saltier the water gets.)

3. Based on your work with the hydrometers, what impact might a decrease in salt water have on the salinity of an estuary? (The water in the estuary will get saltier and the saltwater wedge will move further "up-stream." This means that organisms that are not salt-tolerant will die out or be forced to move, ultimately disrupting the food chain.)

Try This

How do you think a sudden increase of salinity will affect vegetation growing in an estuary? Try this simple experiment. Take two glasses and fill one with salty water and the second with freshwater. Take two pieces of lettuce and place one in each glass. Allow them to sit for three or four days and then take them out and compare how they feel. How might you explain the results?

To see how freshwater and salt water "stack up" against each other, you can make a model estuary by using a small fish tank. Fill the tank about half full with freshwater and put in several drops of food coloring to make it red. Next, mix up a batch of extremely salty water and color it blue. Predict what will happen when you mix the two together and then ***without stirring, slowly*** pour the salt water into the freshwater. Was your prediction correct? Explain.

In the Florida Bay estuary, there are definite boundaries for different organisms depending on the salinity of the water. Do a little research on the types of organisms found there to see how tolerant they are of different salinities. What advantage would an organism that is very tolerant of salinity changes have over one that could only live in a narrow zone? How might this affect the balance of an ecosystem?

Sea salts

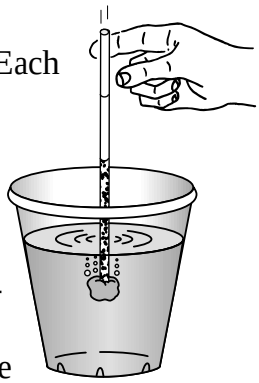
Activity Sheet 2

Name _____ **Class Period**

~~What you're~~ going to do

You and your team will build four different hydrometers and calculate the salinity of three "unknown" water samples.

How to do it



1. Work with your group of four. Each person in the group will build and calibrate one of the "standard" hydrometers.

2. Begin by taking a straw and marking a line around it about 3/4 of the way up. Next, place the masking tape around the top of the straw and write on it the salinity you are calibrating for. It will either be 0.0 % (fresh), 1.0 %, 2.0% or 3.0%. After you have labeled the hydrometer, poke the bottom end of the straw into the modeling clay so that the clay completely seals up the straw.

3. Begin calibrating your hydrometer by placing it into the "standard" solution, clay end first. In the beginning, it will float very high. You must now begin to add sand ***slowly*** to the straw to weigh it down. Your hydrometer is calibrated when the straw sinks into the standard solution so that the line you drew around it exactly lines up with the top of the water in the cup. Once you have reached that point, remove several of the sand grains from the straw and put a small piece of clay in the top of the straw to seal it up. Test your hydrometer again by placing it back into the standard solution. You may have to add a little more clay to get it to exactly balance.

4. Once all the members of your group have calibrated their hydrometers, you should calculate the salinity of the three "unknown" samples. Begin by placing the 0.0 % hydrometer into unknown "A". If it floats higher then the line on the hydrometer, record "higher" on the chart and then test the 1.0% hydrometer. If one of the hydrometers sinks lower then the line on top, record "lower" on the chart. Repeat the procedure until you have tested all four hydrometers on all three solutions. Then use your data chart to approximate the salinity of each sample. Record your prediction on the last column of the chart and compare your group's results to the other groups.

Recording your data

In your science journal set up a data chart like this sample. Use it to record your observations and data from the experiment.

Test Sample	0.0%	1.0%	2.0%	3.0%
Salinity				
"A"				
"B"				
"C"				

What Did You Find Out?

Based on your experiments, how close were your results to those of other class members?

What variables might have caused your results to be different?

Based on your findings, what do you think would happen if equal amounts of samples A and C were mixed together? Why?

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Activity 3

Go With the Flow

How can certain species be used to determine the health of an ecosystem? How do both natural cycles and human intervention change the water balance in an ecosystem? How can you use a water budget to predict what effects water management decisions might have on an ecosystem?

Getting Ready

Overview

Students develop a hypothetical water budget for south Florida and see how factors such as precipitation, evaporation, and diversion of water affect the availability of water in the system. Using the water budget, they attempt to develop a management strategy that will allow a certain minimum flow to go through the system so that all the users have an adequate supply.

Objectives

After completing this activity, students will be able to—

- discuss how changes in rainfall patterns affect the availability of water in a natural system
- predict how changes in rainfall, evaporation, and detention of water will alter the availability of water in an ecosystem
- demonstrate how a water budget can be used to make management decisions for a drainage area

Time Needed

Preparation: Approx. 10 min.
Classroom: Approx. 45 min.

Materials

For the teacher:

- 2-liter soda bottle with the top cut off and three holes punched in the sides along the bottom
- 3 pieces of waterproof electrical tape
- large dish pan
- several wooden blocks
- large pitcher of water

For each student:

- sheet of graph paper
- pencil

Important Terms

evaporation potential — The maximum amount of water that could be evaporated from Earth's surface, usually measured in terms of total inches or centimeters.

indicator species — A species that is used by biologists to tell when an ecosystem is undergoing stress or change.

storage — The amount of water in a system that is held in ponds, lakes, soil, and underground.

water budget — A mathematical model used for predicting the availability of water in a stream channel.

water deficit — The amount of water which is missing from a system when precipitation is less than evaporation.

water surplus — The amount of excess water in a system when precipitation exceeds evaporation.

Everglades

Here's How

Video Clip 4
06:57 to 10:14—Peggy Knapp learns how changes to the Everglades threaten many of the bird species that live there. (3 min. 17 sec.)

Guide on the Side

- You may wish to begin the lesson by viewing the Introduction from the Video Menu on the CD-ROM [00:00 to 00:43]. Find out what students already know about the Everglades. As a class, discuss the questions posed by Sun Me Chomet.
- Before students begin graphing their data, show them the basic mechanics of how the water budget works.
- Review the terms evaporation, precipitation, storage, deficit, and surplus.
- Have students start in the month of January by subtracting the amount of evaporation from the amount of precipitation. If this number is positive, the value is added to the storage.
- Explain that in any month the evaporation is greater than the precipitation, this is considered deficit and that number must be subtracted from storage.
- If it is appropriate, you may wish to view the entire *Newton's Apple* segment on the Everglades after completing this activity.

Answers for Activity Sheet 3:
1) October – April; 2) May-September; 3) You can divert the most water in December because that is when the amount is storage is the greatest; 4) Answers will vary

Month

	J	F	M	A	M	J	J	A	S	O	N	D
P	127	133	142	134	119	115	136	106	73	85	111	152
E	15	18	45	75	122	164	179	170	129	69	31	15
P-E	112	115	97	59	- 3	-49	-43	-64	-56	16	80	137
S	112	115	97	59				16	80	137		
D					3	49	43	64	56			
St	112	227	324	383	380	331	288	224	168	184	264	401

Preparation
- Set up the computer to play the CD-ROM (or set up the VCR and cue the tape).
- Make a copy of Activity Sheet 3 for each student.
- Review the Background information on page 24.

Engage (Approx. 15 min.)

Before class, prepare the demonstration materials on a desk in the front of the room. Using an ice pick or nail, punch three large holes in the soda bottle at three different places. Make sure that they are all in the bottom half of the bottle. Then cover each hole firmly with a piece of waterproof electrical tape. Cut the top off the soda bottle so that it resembles a large beaker and place it inside the dish pan on top of the wooden blocks. The bottle should be visible to all students in the class. Fill the bottle 3/4 full of water and mark the position of the water on the outside of the bottle with a crayon or marker. Fill the large pitcher full of water and place it next to the bottle.

When class begins, ask a student volunteer to come forward to assist with a demonstration. Remove one piece of tape and ask the student to begin slowly pouring water into the top of the soda bottle so that the amount of water in the bottle stays at the same level. Explain to the students that this is a model of the way the Everglades used to be. It's what is called a "steady state system" where the amount of water flowing in equals the amount of water flowing out. Now, with the student filling the bottle at the same rate, remove the other two pieces of tape. Have the class predict what will happen to the level of water in the bottle. (It will drop because the outflow is now greater than the inflow.)

Ask students how this demonstration models what is happening in the Everglades. (Development and farming upstream is just like punching extra holes in the bottle. Little by little, the amount of freshwater entering Florida Bay at the end of the system has dropped steadily.) Ask students if they can think of any impacts this could cause. After a brief discussion, show Video Clip 4 [06:57 to 10:14]. Pause the video clip after Peggy says, "…but man has also tightly regulated the flow of water in the park, and hence the birds have not been able to find enough fish to feed their young." Ask the students if they think people have the right to take water out of the Everglades system if it means that many animals will suffer. Remind them that many people need the water in Florida, and in fact, the fresh fruit students eat is probably grown with this water in the winter time!

Activity 3

Resume playing Video Clip 4 through to the end. Explain that even though the Everglades is in trouble now, there is hope. Managers and land use planners are trying to work out a way to share the water fairly. One way of doing this is with a water budget. A water budget is like a bank account, except instead of taking money in and out, it's water. Deposits happen when it rains, withdrawals happen because of evaporation and people diverting water. Any water left stored in the system is considered savings!

Explain that their mission is to create a water budget for the Everglades to see how seasonal cycles affect the availability of water. Then, based on their data, they have to come up with a management plan showing when and how much water can be diverted from the system. (Note: The data for this particular water budget is similar to a typical year in south Florida. The numbers are hypothetical.)

Explore (Approx. 30 min.)

Have students work in pairs. Pass out Activity Sheet 3. Explain that using the data on the chart, students should complete the water budget chart. Then, using their findings, create a graph showing which months have a surplus and a deficit.

Once they have graphed the data, the next step is for them to create a graph that will show when water can be diverted from the system for other uses. Explain that in an ideal situation, there should be a minimum of 100 inches of water available in storage at all times. This water would be considered the minimum amount needed to keep the Florida Bay estuary productive. If in any month the storage falls below 100 inches, the estuary will undergo stress. Their job is to balance out the water so that both people and animals have enough to go around.

Evaluate

1. Why isn't there a constant flow of water through the Everglades system all year round? (In south Florida, the rainfall has a seasonal pattern creating specific "wet" and "dry" periods.)

2. Even when there is abundant rainfall, fresh water levels in Florida Bay often drop dangerously low. Why does this happen? (Farmers and people in housing developments divert much of the freshwater for their use so that at the bottom of the Everglades system, very little water can get through.)

3. Why do shorebirds make a good "indicator species" for scientists to use to evaluate the health of the Everglades ecosystem? (Indicator species are usually species whose tolerance range for some factor in the ecosystem is very narrow. When these species disappear, it suggests problems with that factor.)

Try This

South Florida is not the only place experiencing problems with having adequate freshwater. Do some research and see if you can create a water budget for your own community. Do you know where your drinking water comes from? What industries need freshwater? Data on rainfall and precipitation can be obtained from the NOAA internet site.

Wetlands used to be thought of as just being "swamps", but people now realize that they provide many valuable uses, including flood control, ground water recharge, and habitat for many animals and plants. Make plans to visit a wetland in your community and see what you can discover on your own about these unique environments.

In some regions, the demand for freshwater is so great that natural rainfall is just not dependable enough. Things like desalinization and water recycling are being considered as ways to make up for the lack of rainfall. The question is, are these really practical ideas? See what you can find out about these technologies. If you're really ambitious, you can try making your own "solar still" for purifying salt water.

Go with the flow

Activity Sheet 3

Name_____ Class Period _____

What you're going to do

You're going to use rainfall and evaporation data to create a hypothetical water budget chart for the south Florida region. You'll use this data to create a water management plan.

How to do it

Work with a partner. Begin subtracting the amount of evaporation from precipitation for each month. If the number is positive, record it under "S" for surplus and add it to the storage. If the number is negative, record it under "D" for deficit and subtract it from storage. We have completed the months of January and February as a model.

Once you have completed the water budget chart, make a graph showing the amount of water that can be taken out of the system each month without causing stress on the ecosystem. In order to keep the ecosystem healthy, you should have at least 100 inches of water available in storage at all times.

Answer the questions below after you have finished the entire investigation.

Water Budget Data Chart

Month	J	F	M	A	M	J	J	A	S	O	N	D
P	127	133	142	134	119	115	136	106	73	85	111	152
E	15	18	45	75	122	164	179	170	129	69	31	15
P–E	112	115										
S	112	115										
D												
St	112	227										

Key: P = Precipitation E = Evaporation S = Surplus D = Deficit St= Storage

What Did You Find Out?

Based on the completed data chart, which months would be considered the "wet season" for South Florida?

Which months would be the "dry season"?

During which month would you be able to safely divert the most water from the system? Why?

Based on your findings, explain how you could divide up the water in the ecosystem so that each user gets his or her "fair share."

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